APPLICATION NO. 10/772,597
INVENTION: Decisioning rules for turbo and convolutional decoding
INVENTORS: Urbain A. von der Embse

Currently amended CLAIMS

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CLAIMS

WHAT IS CLAIMED IS:

Claim **1.(**currently amended) A ~~means~~ method for ~~the~~ performing a new turbo decoding algorithm using a-posteriori probability $p(s,s'|y)$ in equations **(13)** ~~of the invention disclosure of the decoder trellis states s',s for the received codeword k-1,k conditioned on the received symbol set y = {y(1),y(2),. . .,y(k-1),y(k),. . .,y(N)}~~ for defining the maximum a-posteriori probability MAP, comprising: ~~in turbo decoding and which comprises~~:

using a new statistical definition of the MAP logarithm likelihood ratio $L(d(k)|y)$ in equations **(18)**

$$L(d(k))|y) = \ln[\ \Sigma_{(s,s'|d(k)=+1)}\ p(s,s'|y)] \\ -\ln[\ \Sigma_{(s,s'|d(k)=-1)}\ p(s,s'|y)\ ]$$

equal to the natural logarithm of the ratio of the a-posteriori probability $p(s,s'|y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=1$ to the $p(s,s'|y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=0$,

using a factorization of the a-posteriori probability $p(s,s'|y)$ in equations 13 into the product of the a-posteriori probabilities ~~p(s'|y(j<k)),p(s|s',y(k)), p(s|y(j>k))~~

$$p(s,s'|y)=p(s|s',y(k))p(s|y(j>k))p(s'|y(j<k)),$$

using a turbo decoding forward recursion equation ~~for evaluating said a-posteriori probability p(s'|y(j<k)) using said p(s|s',y(k)) as the state transition a-posteriori probability of the trellis~~

$$p(s|y(j<k),y(k)) = \Sigma_{\text{all } s'}\, p(s|s',y(k))\ p(s'|y(j<k))$$

for evaluating said a-posteriori probsbility $p(s'|y(j<k))$ in equations 14 using $p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition path $s' \rightarrow s$ to the new state s at k from the previous state s' at k-1 and given the observed symbol y(k) to update these recursions for the assumed value of the user data bits d(k) equivalent to the transmitted symbol x(k) which is the modulated symbol corresponding to d(k),

using a turbo decoding backward recursion equation ~~for evaluating said a-posterior probability p(s|y(j>k)) using said p(s'|s,y(k)) as the state transition a-posteriori~~

$$p(s'|y(j>k-1) = \Sigma_{\text{all } s}\, p(s|y(j>k))p(s'|s,y(k))$$

for evaluating the a-posterior probability $p(s|y(j>k))$ in equations 15 using said $p(s'|s,y(k)) = p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition pa ~~equivalent to said transmitted symbol x(k) which is the modulated symbol corresponding to said d(k) and where said p(s'|s,y(k))=p(s|s',y(k)),~~

evaluating the natural logarithm of the state transition a-posteriori probability $p(s|s',y(k))=p(s'|s,y(k))$ ~~as a function which is linear in the received symbol y(k)~~equal to the new decisioning metric DX in equations 11,16, defined by equation

$\ln[p(s|s',y(k))$ $\underline{= \ln[p(s'|s,y(k))]}$

$\underline{\qquad\qquad} = \mathrm{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k))$

$\underline{\qquad\qquad = DX}$

~~and~~ wherein p is the natural logarithm ln of p, x* is the comp~~e~~lex conjugate of x, and ln[o] is the natural logarithm of [o]~~,~~

~~evaluating said natural logarithm of said state transition a-posteriori probability p(s'|s,y(k))=p(s|s',y(k)) equal to the new decisioning metric DX in equations **(11),(16)**~~

$\cancel{\ln[p(s|s',y(k))] = \ln[p(s'|s,y(k))]}$

$\cancel{=\mathrm{Re}[y(k)x^*(k)]/\sigma^2 + |x(k)|^2/2\sigma^2 + \underline{p}(d(k)}$

$\cancel{= DX}$

~~and which is linear in said received symbol y(k),~~

whereby said new state transition probabilities in said MAP equations use said DX linear in y(k) in place of the current use of the maximum likelihood decisioning metric DM=[$-|y(k) - x(k)|^2/2\sigma^2$] which is a quadratic function of y(k),

$\cancel{DM = [\ -|y(k) - x(k)|^2/2\sigma^2\ ],}$

~~which is a quadratic function of y(k),~~

whereby said MAP turbo decoding algorithms ~~realizes~~ provide some ~~-~~of the performance improvements demonstrated in FIG. **5,6** using said DX, and~~,~~

~~said~~ whereby this new a-posteriori mathematical framework enables said MAP turbo decoding algorithms to be restructured and to determine the intrinsic information as a function of said DX linear in said y(k).

Claim **2**. (currently amended) ~~Wherein in claim 1 a~~A method for performing ~~means for said~~ a new convolutional decoding algorithm ~~in said~~using the MAP a-posteriori probability $p(s,s'|y)$ ~~and which comprises~~in equations 13, comprising::

using a new maximum a-posteriori principle which maximizes the a-posteriori probability $p(x|y)$ of the transmitted symbol x given the received symbol y to replace the current maximum likelihood principle which maximizes the likelihood probability $p(y|x)$ of y given x for deriving the forward and the backward recursive equations to implement convolutional decoding,

using ~~said~~ the factorization of ~~said~~ the a-posteriori probability $p(s,s'|y)$ in equations 13 into the product of said a-posteriori probabilities $p(s'|y(j<k))$, $p(s|s',y(k))$, $p(s|y(j>k))$ to identify the convolutional decoding forward state metric $a_{k-1}(s')$, backward state metric $b_k(s)$, and state transition metric $p_k(s|s')$ as the a-posteriori probability factors

$$
\begin{aligned}
p_k(s|s') &= p(s|s',y(k)) \\
b_k(s) &= p(s|y(j>k)) \\
a_{k-1}(s') &= p(s'|y(j<k)),
\end{aligned}
$$

using a convolutional decoding forward recursion equation in equations 14 for evaluating said a-posteriori probability $a_k(s)=p(s|y(j<k),y(k))$ using said $p_k(s|s')=p(s|s',y(k))$ as said state transition probability of the trellis transition path $s' \rightarrow s$ to the new state s at k from the previous state s' at k-1,

using a convolutional decoding backward recursion equation in equations 15 for evaluating said a-posteriori probability $b_k(s)=p(s|y(j>k))$ using said $p_k(s'|s)=p(s'|s,y(k))$ as said state transition probability

of the trellis transition path s→s′ to the new state s′ at k-1 from the previous state s at k,

evaluating the natural logarithm of said state_transition a-posteriori_probabilities

$$\ln[p_k(s'|s)] = \ln[p(s'|s,y(k))]$$
$$= \ln[p(s|s',y(k))]$$
$$= \ln[p_k(s|s')]$$
$$= DX$$

equal to ~~said~~ the new decisioning metric DX in equations 16, and~~,~~

implementing said convolutional decoding algorithms to ~~realize~~obtain some of the~~—~~performance improvements demonstrated in FIG. **5**,**6** using said DX.

Claim **3**. (currently amended) Wherein_in claim ~~**1**~~**2** ~~A means for~~a method for implementing the new convolutional decoding recursive equations,~~, which calculate said MAP a-posteriori probability p(s,s′|y)~~ said method comprising:~~and which comprises: said~~ implementing in equations 14 a forward recursion equation for evaluating ~~said~~the natural logarithm,, a_k, of a_k using ~~said p_k=ln[p(s|s′,y(k))] as~~ the natural logarithm ~~said~~ of the state transition a-posteriori probability $p_k=\ln[p(s|s',y(k))]$ of the trellis transition path s′→s to the new state s at k from the previous state s′ at k-1, which is equation ~~and is~~

$$\underline{a}_k(s) = \max_{s'} [\underline{a}_{k-1}(s') + \underline{p}_k(s|s')]$$
$$= \max_{s'} [\underline{a}_{k-1}(s') + DX(s|s')]$$
$$= \max_{s'} [\underline{a}_{k-1}(s') + \mathrm{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k))]$$

wherein said $DX(s|s')=p_k(s|s')]=p_k(s'|s)=DX(s'|s)=DX$ is ~~said~~ the new decisioning metric, and ~~said~~ implementing in equations 15 a backward recursion equation for evaluating ~~said~~ the natural logarithm, b_k. of b_k using ~~said $p_k=\ln[p(s'|s,y(k))]=\ln[p(s|s',y(k))]$ as~~ the natural logarithm of said state transition a-posteriori probability $p_k=\ln[p(s'|s,y(k))]=\ln[p(s|s',y(k))]$ of the trellis transition path $s \rightarrow s'$ to the new state s' at $k-1$ and is equation

$$b_{k-1}(s') = \max_{s} [b_k(s) + DX(s'|s)].\ \cancel{\text{and,}}$$

~~said decoding algorithms realize some of the performanceimprovements demonstrated in FIG. **5,6** using said DX.~~